DIN 17178 Welded circular fine grain steel tubes subject to special requirements
Technical delivery conditions

The subclauses marked with a single dot ● give specifications which are to be agreed upon at the time of ordering. The subclauses marked with two dots ●● give specifications which are optional and may be agreed upon at the time of ordering.

1. Field of application

1.1 This standard applies to welded circular tubes subject to special requirements and made from the fine grain structural steels listed in table. 1. These tubes are intended to be used on the basis of a 100% utilization of the permissible design stress in the weld. They are predominantly used in the construction of pressure vessels, chemical plant, pipework and for general mechanical engineering purposes. They are designed for operating temperatures not exceeding 400°C and, in the as delivered condition (see subclause 5.2), normally exhibit a minimum yield strength of between 255 and 460N/mm², as given for the lowest wall thickness range in table 3.

1.2 This standard does not apply to

- welded circular fine grain structural steel tubes for structural steel work as specified in DIN 17123;
- steel tubes for pipelines conveying combustible liquids and gases as specified in DIN 17172;
- electrically pressure welded heat resisting steel tubes as specified in DIN 17177;
- welded precision steel tubes as specified in DIN 2393 Part 2;
- welded and sized precision steel tubes as specified in DIN 2394 Part 2.

2. Concept

For the purposes of this standard, fine grain structural steels are steels with a minimum yield strength between 255 and 460N/mm ², whose chemical composition is selected so as to ensure weldability, this being a function of the minimum yield strength. The steels are fully killed and contain elements forming precipitations, e.g. nitrides and/or carbonitrides. These prevent the growth of crystal grains in the austenite region and lead to a fine grain in the as delivered condition (ferrite grain size 6 and finer when tested as described in DIN 50 601). Thus, the steels of this type are highly resistant to brittle fracture.

3. Classification into grades

3.1 This standard comprises four series of steel grades as listed in table 1:

a) the basic (StE) series:

b) the high temperature (WStE) series including grades which are to have a 0.2% proof stress at elevated temperatures (see table 4);

c) the low temperature (TStE) series including grades which are to have a minimum impact energy down to temperatures of - 50°C (see table 5);

d) the special low temperature (EStE) series including grades which are to have a minimum impact energy down to temperatures of - 60°C (see table 5).

● The selection of the steel grade is at the purchaser's discretion.

3.2 ●●It may be agreed at the time of ordering that the minimum elevated temperature 0.2% proof stress values given in table 4 for the steels of the high temperature series shall

also apply for the steels of the low temperature and special low temperature series.

4. Designation and ordering

4.1 ●The standard designation for tubes complying with this standard shall give in the following order:

- the name of product (tube);
- the DIN number of the dimensional standard (e.g. DIN 2458)
- characteristic dimensions of the tube (outside diameter x wall thickness);
- the DIN number of the present standard (DIN 17178);
- the symbol or material number identifying the steel grade (see table 1).

Example: A welded tube conforming to this standard, with an outside diameter of 114.3mm and a wall thick-ness of 3.6mm as specified in DIN 2458, made from steel TStE 355 (material number 1.0566) shall be designated Tube KIN 2458 - 114.3X3.6-DIN 17178-TStE 355 or Tube DIN 2458 - 114.3x3.6-DIN 17178-1.0566

4.2 ●In addition to the standard designation as specified in subclause 4.1, the order shall always give the quantity required (e.g. total length to be supplied), the type of length (see table 6), the length of the individual tube in the case of specified lengths and exact lengths, the type of materials testing certificate as specified in DIN 50049 or any additional relevant technical rule or code of practice.

Example of an order: 1000m tube DIN 2458 - 114.3 X 3.6 - DIN 17178 -TStE 355, in specified lengths of 8m, certificate DIN 50049 - 3.1B

4.3 ●●In addition, further details such as are specified in the subclauses marked with two dots may be agreed at the time of ordering.

5. Requirements

5.1 Manufacturing process

5.1.1 The steel shall be produced either by the basic oxygen process, the open hearth process or in the electric furnace.

5.1.1.1 ●● Subject to agreement with the purchaser, an alternative equivalent process may be used.

5.1.1.2 ●● If so agreed, the purchaser shall be informed on the steelmaking process used.

5.1.2 The steel shall be fully killed, shall have sufficient elements for nitrogen control and shall be fine grained (see clause2).

5.1.3 ●●Unless otherwise agreed at the time of ordering, the process used to manufacture the tubes is left to the manufacturer's discretion.

The tubes shall be fabricated by joining appropriately bent sheet or strip in a fully mechanized welding process, generally by means of double-sided submerged-arc fusion welding, carried out in such a way that a longitudinal weld or a spiral weld is produced, or by means of electric pressure welding in such a way that a longitudinal weld is produced. If necessary, the tubes shall additionally be hot reduced, cold drawn or brought to their ultimate size by drifting or rolling to size.

There shall be no strip joining welds in the pressure welded tubes supplied.

5.1.4 The welding process shall be inspected to ensure that welds are properly carried out. Welding shall be carried out in such a way that a penetration weld is produced and that the tube can be used on the basis of a 100% utilization of the permissible design stress in the weld.

5.1.5 In the case of fusion welded tubes, the welds shall be made from both sides. Electrically pressure welded tubes shall be supplied without external upset. The internal upset of tubes having inside diameters not smaller than 20mm shall not exceed the values specified in subclause 2.10.4 b

●In he case of electrically pressure welded tubes having inside diameters smaller than 20mm an agreement shall be reached with regard to the internal upset.

Local repair of welds is permitted. The purchaser may, on one occasion only, request a document certifying the suit-ability of the process employed for repairing the welds, as specified in subclause 5.1.7. Areas that are repaired shall then be subjected to non-destructive testing; in addition, the tube shall be tested for soundness.

5.1.6 The manufacturer's works shall have at its disposal the specialists and suitable equipment or shall employ appropriate processes to enable welding work to be properly carried out, inspected and tested.

5.1.7 ●●The purchaser may on one occasion only request a document certifying compliance with the requirements specified in subclause 5.1.6. The details of this document, in particular with regard to the test house, shall be agreed between manufacturer and purchaser. This document shall be considered valid only for the steel grades, dimensional ranges, welding processes and filler metals to which it refers.

5.2 As delivered condition

5.2.1 The tubes shall be supplied in the normalized condition

Normalizing of the tubes may be dispensed with

a) if, in the case of tubes intended to be cold formed, the starting products (plate, sheet or strip) are used in the normalized condition 1), if necessary with subsequent annealing of the weld zone, or

b) if, in the case of steel grades having a minimum yield strength not exceeding 355N/mm², the final forming operation in tube production is normalizing forming ensuring a condition equivalent to normalizing (see Stahl-Eisen-Werkstoffblatt (Iron and steel materials sheet)082).

Normalizing of the starting products for tube production may be substituted by normalizing forming in the case of steel grades having a minimum yield strength not exceeding 355N/mm².

5.2.2 In the case of tubes with a small wall thickness and made from steel grades having a minimum yield strength not less than 420N/mm², a delayed cooling or additional tempering may be needed.

5.2.3 ●●If the surface of the tubes is to be provided with an anti-corrosive agent with a limited life, this shall be agreed at the time of ordering.

5.2.4 ●●If special requirements are made on the tubes with regard to further processing (e.g. galvanizing), this shall be agreed at the time of ordering.

5.3 Chemical composition

5.3.1 Chemical composition as determined by the cast analysis

The chemical composition of the steels as determined by the cast analysis 2) is given in table 1.

The table specifies the permissible contents of the individual alloying elements. The manufacturer shall inform the purchaser on the types of alloying element used and on the associated percentages, for the steel grade supplied.

1) If tubes are to be used in plant subject to regular inspection, consideration shall be given to the specifications for heat treatment provided in the relevant codes of practice for particular cases where overstressing during cold forming occurs.

2) When sequential castings are supplied as is possible with continuously cast tubes the term "cast" should be read as "casting unit".

Table 1. Chemical composition as determined by the cast analysis

Steel grade	% by mass

Symbol	Material number	C ≤	Si .	Mn .	P ≤	S ≤	N ≤	ALx1) ≥	Cr ≤	Cu ≤	Mo ≤	Ni ≤	Nb ≤	Ti ≤	V ≤	Nb+Ti+V ≤
StE255	1.0461	0.18	≤0.40	0.05 to 1.30	0.035	0.030	0.020	0.020	0.30 2)	0.20 2)	0.08 2)	0.30	0.03	-	-	0.05
WStE255	1.0462	0.18			0.035	0.030										
TStE255	1.0463	0.16			0.030	0.025										
EStE255	1.1103	0.16			0.025	0.015										
StE285	1.0486	0.18		0.60 to 1.40	0.035	0.030										
WStE285	1.0487	0.18			0.035	0.030										
TStE285	1.0488	0.16			0.030	0.025										
EStE285	1.1104	0.16			0.025	0.015										
StE355	1.0562	0.20	0.10 to 0.50	0.90 to 1.65	0.035	0.030						0.30 4)	0.05		0.10	0.12
WStE355	1.0565	0.20			0.035	0.030										
TStE355	1.0566	0.18			0.030	0.025										
EStE355	1.1106	0.18			0.025	0.015										
StE420	1.8902	0.20	0.10 to 0.60	1.00 to 1.70	0.035	0.030			0.30	0.20 3)	0.10	1.00		- 5)	0.20	0.22
WStE420	1.8932				0.035	0.030										
TStE420	1.8912				0.030	0.025										
EStE420	1.8913				0.025	0.015										
StE460	1.8905				0.035	0.030										
WStE460	1.8935				0.035	0.030										
TStE460	1.8915				0.030	0.025										
EStE460	1.8918				0.025	0.015										

1) If nitrogen is additionally controlled by niobium, titanium or vanadium, the requirement for a minimum aluminum content need not be complied with.

2) The sum of the contents by mass of chromium, copper and molybdenum shall not exceed 0.45%.

3) If copper is added as an alloying element, the maximum content by mass may be 0.70%.

4) If nickel is added as an alloying element, the maximum content by mass may be 0.85%.

5) If titanium is added as an alloying element, the maximum content by mass may be 0.20%.

5.3.2 ●●Chemical composition as determined by the product analysis

If checking of the chemical composition on the product has been agreed at the time of ordering, the results of the product analysis shall be allowed to deviate, by the amounts stated in table 2, from the limit values for the cast analysis to be notified by the manufacturer.

Table 2 Amounts by which the chemical composition as determined by the product analysis may deviate from the limit values to be stated by the manufacturer for the cast analysis (see subclause 5.3.2)

Element	Limit values specified for the cast analysis as in table 1 % by mass	Permissible deviations of results of product analysis from the limit values as determined by the cast analysis 1) %by mass
C	≤0.20	0.02
Si	≤0.60	0.05
Mn	≤1.00 ＞1.00 ≤1.70	0.06 0.10
P	≤0.035	0.005
S	≤0.030	0.005
Cr	≤0.30	0.04
Cu	≤0.70	0.07
Mo	≤0.10	0.03
Ni	≤1.00	0.05
Nb	≤0.05	0.01
Ti	≤0.20	0.02
V	≤0.20	0.02
N	≤0.020	0.002
1) If several product analyses are carried out for a single cast and if these elements show contents for a single element outside the range specified for the cast analysis, this content shall either exceed the permissible maximum content or be below the permissible minimum content, but not both at the same time for one cast.		

5.4 Mechanical properties

5.4.1 The values of yield stress, tensile strength, elongation after fracture and impact energy given in table 3.4 and 5 for tubes with a wall thickness not exceeding 40mm are based on the test conditions given in clause 6 and shall apply for the as delivered condition as specified in sub-clauses 5.2.1 and 5.2.2.

The minimum values of yield stress and tensile strength shall also apply for the weld.

Table 3 Mechanical properties of tubes with a wall thickness not exceeding 40mm 1)

Steel grade								Mechanical properties						
Basic series		High temperature series		Low temperature series		Special low temperature series		Minimum upper yield stress Rx 2), for wall thickness, in mm, of			Tensile strength Rx	Minimum elongation after fracture, Ax when testing test pieces taken		Bend mandrel diameter for the technological bend test of fusion welded tubes 3)
Symbol	Material number	Symbol	Material number	Symbol	Material number	Symbol	Material number	up to 12	over 12 up to 12	over12 up to 12		parallel	transverse	
								N/mm²			N/mm²	to the tube axis		
StE 255 StE 285 StE 355	1.0461 1.0486 1.0562	WStE 255 WStE 285 WStE 355	1.0462 1.0487 1.0565	TStE 255 TStE 285 TStE 355	1.0463 1.0488 1.0566	EStE 255 EStE 285 EStE 355	1.1103 1.1104 1.1106	255 285 355		245 275 345	360 to 480 4) 390 to 510 4) 490 to 630 4)	23 24 22	23 22 20	2 s 2 s 3 s
StE 420 StE 460	1.8902 1.8905	WStE 420 WStE 460	1.8932 1.8935	TStE 420 TStE 460	1.8912 1.8915	EStE 420 EStE 460	1.8913 1.8918	420 460	410 450	400 440	530 to 680 560 to 730	21 19	19 17	3.5 s 4 s

1) ●For wall thicknesses exceeding 40mm, the values shall be agreed at the time of ordering.

2) If the yield stress cannot be easily recognized, the values shall apply for the 0.2% proof stress.

3) s is the wall thickness of the tube, bend angle = 180° (see subclause 6.5.5)

4) No objections shall be made if the upper limit is exceeded by up to 20N/mm²

5.4.2 ●●If tubes are subjected to stresses vertical to their axis, which will normally occur in the case of wall thick-nesses equal to or exceeding 20mm, minimum values of reduction in area after fracture as laid down in Stahl-Eisen-Lieferbedingungen (Iron and steel delivery conditions) 096 may be agreed at the time of ordering.

5.4.3 The minimum values of elevated temperature 0.2% proof stress as given in table 4 shall apply for tubes made from the steel grades of the high temperature series and also for those of the low temperature series if this has been agreed at the time of ordering.

5.4.4 For characterizing the susceptibility to brittle fracture table 5 gives minimum values of impact energy deter-mined on ISO(V-notch)standard test pieces taken at different test temperatures and in different directions.

In the case of tubes with outside diameters not exceeding 500mm, the values specified in table 5 shall apply for test pieces taken in the longitudinal direction. In the case of tubes with outside diameter exceeding 500mm, the values specified shall apply for test pieces taken transverse to the tube axis or transverse to the weld.

Table 4 Values of elevated temperature 0.2% proof stress 1)

Steel grade		Wall thickness	Minimum values of 0.2% proof stress at a test temperature of						
Symbol	Material number		100°C	150°C	200°C	250°C	300°C	350°C	400°C
		in mm	N/mm²						
WStE 255	1.0462	Up to 20	226	206	186	167	137	118	108
		Over 20 up to 40	216	196					
WStE 285	1.0487	Up to 20	255	235	206	186	157	137	118
		Over 20 up to 40	245	226					
WStE 355	1.0565	Up to 20	304	284	255	235	216	196	167
		Over 20 up to 40	294	275					
WStE 420	1.8932	Up to 12	363	343	314	284	265	235	206
		Over 12 up to 20	353	333					
		Over 20 up to 40	343	324	304	275	255	226	196
WStE 460	1.8935	Up to 12	402	373	343	314	294	265	235
		Over 12 up to 20	392	363					
		Over 20 up to 40	382	353	333	304	284	255	226
1) ●In the case of wall thicknesses exceeding 40mm, the values shall be agreed at the time of ordering.									

Table 5 Impact energy requirements to be met in impact tests on ISO standard test pieces

Steel grades as in tables 1 and 3	Direction of sampling 1)	Minimum values of impact energy, Ax for a wall thickness, s, from 10 to 40mm 1)2) at a test temperature, in °C, of								
		-60	-50	-40	-30	-20	-10	0	+10	+20
		J								

Basic series and high temperature series	Longitudinal	-	-	-	-	39	43	47	51	55
	Transverse	-	-	-	-	21	24	31	31	31
Low temperature series	Longitudinal	-	27	31	39	47	51	55	59	63
	Transverse	-	16	20	24	27	31	31	35	39
Special low temperature series	Longitudinal	25	30	40	50	65	80	90	95	100
	Transverse	20	27	30	35	45	60	70	75	80
1) See also subclauses 5.4.4 and 6.5.2 2) ● In the case of wall thicknesses exceeding 40mm, the values shall be agreed at the time of ordering.										

5.4.4.1 ●●Subject to agreement at the time of ordering for tubes with outside diameters not exceeding 500mm, the values specified in table 5 shall also apply for test pieces taken transverse to the tube axis or transverse to the weld provided that the tube dimensions permit ISO standard test pieces to be taken as described in DIN 50115 without straightening of the tube.

5.4.5 Tubes made from the steel grades specified in this standard are cold and hot workable (see Stahl-Eisen-Werk-stoffblatt 088). They shall fulfill the requirements to be tested as described in subclauses 6.5.3 to 6.5.5.

5.5 Weldability

Tubes made from the steel grades complying with this standard are weldable, if the generally recognized rules of the art (see Stahl-Eisen-Werkstoffblatt 088) are observed.

5.6 Heat treatment and further processing

5.6.1 The temperatures for normalizing the steel grades are a function of their chemical composition.

Although the normalizing temperature may not differ from one works to the next for one and the same steel grade (see subclause 5.3.1), it shall generally be between 880 and 960°C.

5.6.2 Stress relieving shall be performed at temperatures between 530 and 580°C, with cooling in still air. The holding period (as specified in DIN 17014 Part 1) shall not exceed 150 minutes. Where the holding period exceeds 90minutes, the lower limit of the temperature range shall be aimed at.

5.6.3 In the event of further processing of the steels com-plying with this standard, the data specified in Stahl-Eisen-Werkstoffblatt 088 and in the certificate (see sub-clause 5.1.7) shall be observed.

5.7 Appearance of surface and weld

5.7.1 Tubes shall have a smooth internal and external surface consistent with the manufacturing process.

5.7.2 Slight irregularities in the surface such as raised or depressed areas or shallow grooves resulting from the remaining wall thickness continues to meet the requirements specified in subclause 5.10.2.2 and the function of the tube is not impaired (see subclause 8.1).

5.7.3 Proper removal of shallow surface defects using appropriate means is permitted provided that the remaining wall thickness continues to meet the requirements specified in subclause 5.10.2.2. Stopping of surface defects is not permitted.

5.8 Soundness

The tubes shall be sound when tested as specified in sub-clause 6.3.7.1.

5.9 Non-destructive testing

The requirements given in Stahl-Eisen-Prufblatt(Iron and steel testing sheet) 1916 or 1917 are to be met in the non-destructive tests specified in subclause 6.5.9.

5.9.1 ●● Ultrasonic testing as specified in Stahl-Eisen-Prufblatt 1915 may be agreed for pressure welded tubes.

5.10 Dimensions, masses per unit length and permissible deviations

5.10.1 Dimensions

5.10.1.1 DIN 2458 shall apply for the outside diameter and wall thickness of tubes.

5.10.1.2 Table 6 shall apply for the types of tube length.

Table 6.Types of tube length and permissible deviations in length

Type of length		Permissible deviations in length, in mm, for outside diameters	
		≤500	＞500
Manufacturing length 1)		1)	1)
Specified length		±500	±500
Exact length	up to and including 6m	+10 0	+25 0
	over 6 up to and including 12m	+15 0	+50 0
	over 12m	By agreement.	

1) The tubes are supplied in the manufacturing lengths occurring in production.

●These lengths are a function of the tube outside diameter, wall thickness and manufacturer's works and shall be agreed at the time of ordering.

5.10.2 Permissible dimensional deviations

5.10.2.1 The information given in table 7 (see sub-clause 6.5.11) shall apply for the permissible deviations in outside diameter dx

5.10.2.1.1 ●●For the tube ends, the lower permissible deviations in diameter given in table 7 may also be agreed.

5.10.2.2 The permissible deviations in wall thickness, s, shall be:

for s ≤ 3mm : +0.30mm, -0.25mm;

for s over 3mm up to and including 10mm : +0.45 3) mm, -0.35mm;

for s ＞10mm : -0.50mm, the upper limit being given by the permissible deviation in mass.

At isolated points, the wall thickness may be up to 5% smaller than the minimum wall thickness resulting from the permissible lower deviation, for lengths not greater than twice

the outside diameter of the tube, and for net more than a maximum of 300mm. This is intended to take account of points where the defects have been removed by grinding (see subclause 5.10.4 for the permitted weld reinforcement). Misaligned weld edges in pressure welded tubes, where the reduction in cross section exceeds the permissible lower deviation in wall thickness are net permitted.

5.10.2.3 ●●In special cases, by agreement at the time of ordering, tubes may be supplied in accordance with these technical delivery conditions with the permissible deviations in outside diameter and wall thickness specified in DIN 2393 Part 1 or DIN 2394 Part 1.

5.10.2.4 The permissible deviations in length are given in Table 5.

3) The upper limit for tubes made from heavy plate is given by the permissible deviation in mass.

Table 7 Permissible deviations in outside diameter and from circularity

Outside diameter, dx, in mm	Permissible deviation in diameter		Permissible deviation of tube barrel from circularity 2)
	of tube barrel and at tube ends	●●at tube ends1), subject to particular agreement	
dx＜200	±1%·dx (values up to ±0.5mm are permitted in all cases)	±0.5%·dx (values up to ±0.3mm are permitted in all cases)	Not exceeding the permissible deviation in diameter
200≤dx＜325	±(0.5%·dx+1)mm ³)	±1.0mm	2%;(this value is not guaranteed for x exceeding 100)
325≤dx＜1000		±1.6mm	
1000≤dx	±6mm ³)	By agreement 4)	

1) This covers a zone of about 100mm from the tube ends.

2) See subclause 5.10.3.1

3) ●● Subject to agreement at the time of ordering, in the case of tubes with an outside diameter exceeding 500mm, the permissible deviation may also be specified as a function of the inside diameter, in which case the permissible deviation in wall thickness is to be taken into account.

4) ●●Subject to agreement at the time of ordering the permissible deviation may also be referred to the inside diameter, in which case the permissible deviation in wall thickness is to be taken into account.

5.10.3 Permissible deviations of form

5.10.3.1 Circularity

Tubes shall be as circular as possible. The permissible deviations from circularity are specified in table 7. The out-of-roundness, R, (see subclause 6.5.12) shall be determined using the following formula:

where

dxx is the greatest outside diameter measured;

dxx is the greatest outside diameter measured.

5.10.3.2 Straightness

5.10.3.2.1 Tubes shall be straight to the eye.

5.10.3.2.2 ●●Particular requirements regarding straight-ness may be agreed.

5.10.4 Permissible weld reinforcement

The weld reinforcement, x, shall net exceed the following values, as a function of the wall thickness, s:

a) for fusion welded tubes:

for s ≤8mm x≤2.5mm

for s over 8mm up to and including 14mm,

x ≤ 3.0mm;

for s over 14mm up to and including 40mm,

x≤4.0mm

b) for pressure welded tubes;

after the upset has been removed, the inside weld reinforcement shall net exceed 0.3mm in the case of inside diameters not smaller than 20mm.

5.10.5 Finish of tube ends

5.10.5.1 Tube ends shall be cut perpendicular to the tube axis and shall be free from burr.

5.10.5.2 ●●Subject to agreement, tubes with s not smaller than 3.2mm may be supplied with end faces prepared for butt welding and exhibiting the following finish:

- the bevel of groove flank shall be 30°x,
- the thickness of the root face shall be (1,6±0.8) mm.

Other types of edge preparation are subject to particular agreement.

5.10.6 Masses per unit length

The masses per unit length shall comply with the values specified in DIN 2458. For tubes in non-standard sizes, the mass per unit length shall be calculated taking the density as 7,85kg/dm³ for all steel grades.

6.Testing and materials testing certificates

6.1 General

Tubes complying with this standard may be supplied with one of the following materials testing certificates as specified in DIN 50049;

- certificate DIN 50049 - 3.1 A (inspection certificate A);
- certificate DIN 50049 - 3.1 B (inspection certificate B);
- certificate DIN 50049 - 3.1 C (inspection certificate C).

●The type of certificate required and the test house where acceptance inspection is to be carried out by a third party shall be stated at the time of ordering.

6.2 Test site

The tubes shall be tested at the manufacturer's works. Production at the manufacturer's works shall net be unduly disturbed when acceptance inspection is carried out by experts

who are not employees of the manufacturer.

6.3 Scope of test program

Table 9 shows a summary of the scope of test program in each case.

6.3.1 The tubes shall be inspected by batches.

For the purposes of testing, the tubes shall be divided by steel grade and, if possible, also by casts, dimensions and heat treatment units as a function of the outside diameter, dx, into batches each comprising the following numbers of tubes:

for dx ≤ 500mm, 100 tubes;

for dx ＞ 500mm, 50 tubes.

Remainders of up to 50% of a batch may be distributed uniformly across the other batches. Numbers of tubes and remainders amounting to more than 50% and consignments of more than 10, but not more than 50 tubes count as one complete batch.

Testing of strip joining welds on spirally welded tubes shall be carried out on batches comprising 50 tubes with strip joining welds.

6.3.2 Two sample tubes shall be taken at the inspector's discretion from each of the two first batches (see sub-clause 6.3.1) and one sample tube from each further batch for the purposes of testing as specified in subclauses 6.4.1 and 6.4.2 (tensile test and impact test); sampling shall ensure that every cast is represented.

6.3.3 One sample tube shall be taken where consignments are 10 tubes or less.

6.3.4 The following tests shall be carried out on test pieces taken from the sample tubes as specified in sub-clauses 6.3.2 and 6.3.3:

- tensile test of the parent metal;
- additional tensile test on test pieces taking transverse to the weld in the case of tubes exceeding 500mm outside diameter;
- impact test of the parent metal in the case of wall thick-nesses not smaller than 5mm;
- additional impact test on test pieces with a weld (impact on center of weld) in the case of tubes with an outside diameter exceeding 500mm and a wall thickness not less than 10mm;
- flattening test for pressure welded tubes (if the weld is not recognizable, the drift expanding test shall be carried out instead);
- bend test for fusion welded tubes.

6.3.5 ●● If it has been agreed at the time of ordering to check the chemical composition (product analysis), this analysis shall be carried out on one tube per cast.

6.3.6 ●● If it has been agreed at the time of ordering to verify the elevated temperature 0.2% proof stress, this analysis shall be carried out on one tube per cast.

6.3.7 Furthermore,

6.3.7.1 all tubes shall be tested at ted manufacturer's works for soundness, normally by means of a hydraulic test (see subclause 6.5.7). If, under the test conditions specified in subclause 6.5.7 (test pressure:80bar), a load limit of 0.7 x Rx (equivalent to a safety factor of about 1.5 against the yield stress) is not exceeded, then, at the manufacturer′s discretion, instead of the hydraulic test a suitable non-destructive test method (an eddy current test as specified in Stahl-Eisen-Prufblatt 1925, for example) may be used for testing the soundness.

6.3.7.2 all tubes shall be inspected inside and outside for their surface appearance;

6.3.7.3 all tubes shall be inspected for their accuracy to size as specified in subclause 5.10;

6.3.7.4 during the process of manufacture, the whole length of welded joints of all tubes shall be subjected to non0destructive testing.

6.4 Sampling and sample preparation

See figure 1 for the sampling points and the location of test pieces.

6.4.1 Tensile test

6.4.1.1 In the case of tubes with outside diameters not greater than 500mm, one strip test piece (see DIN 50140) shall be taking from the parent metal of the sample tube, longitudinal to the tube axis and offset from the weld by about 90°. The test piece shall not be heat treated and not straightened within the gauge length. At the manufacturer's discretion, tubes may also be subjected to the tensile test in full (see DIN 50140).

6.4.1.2 In the case of tubes with outside diameters equal to or greater than 200mm, at the manufacturer's discretion, a flat test piece (see DIN 50125) may also be taken from the parent metal transverse to the tube axis. The test piece shall be cold straightened and may be annealed at a temperature below 500°C.

6.4.1.3 In the case of tubes with outside diameters greater than 500mm, a flat test piece as illustrated in figure 1 of DIN 50 120 Part 1, September 1975 edition, or in figure 2 of DIN 50 120 Part 2, August 1978 edition, shall be taken trans-verse to the weld with the weld in the center and one flat test piece (see DIN 50125) transverse to the tube axis and offset from the weld by about 90,°. The test pieces shall be cold straightened and may be annealed at a temperature below 500°C.

6.4.1.4 Instead of sampling as described in subclause

6.4.1.2, at the manufacturer's discretion, it is also permitted to take an unstraightened test piece worked on all sides (see DIN 50125) transverse to the tube axis for testing the parent metal.

6.4.1.5 Normally, short proportional test pieces shall be taken for the tensile testing of the parent metal. If the test pieces are not worked on all sides it is permitted to remove local irregularities, the rolling skin shall however be retained at the thinnest spots.

For strip joining welds on spirally welded tubes, the same specifications shall apply as for the other welds.

6.4.1.6 ●● If minimum values of reduction in area ater fracture have been agreed at the time of ordering, testing shall be carried out on the basis of Stahl-Eisen-Lieferbedin-gungen 096, the scope of test program being the subject of a particular agreement.

6.4.2 Impact test

For the purposes of impact testing of the parent metal, a set of three ISO standard test pieces shall be taken from the sample tube as follows;

- in the case of tubes with outside diameter not exceeding 500mm, longitudinal to the tube axis;
- in the case of tubes with outside diameter exceeding 500mm, transverse to the tube axis, if the tube dimensions permit this without straightening of the tube;
-●● in the case of tubes with outside diameter not exceeding 500mm, transverse to the tube axis, if this has been agreed at the time of ordering (see sub-clause 5.4.4.1) and the tube dimensions permit standard test pieces to be taken.

In the case of tubes the wall thickness of which exceeds 30mm, the center line of the test pieces shall have a distance from the external surface equal to one quarter of the wall thickness or shall be positioned as close as possible to this location.

For the purposes of the impact test carried out in the center of the weld, a set of three ISO standard test pieces shall be taken from the sample tube transverse to the weld. If the wall thickness is inadequate for the manufacture of ISO standard test pieces, test pieces shall be taken whose the wall thickness, but whose other dimensions correspond to those of ISO standard test pieces, in the case of wall thicknesses from 5mm to 10mm (see subclause 6.5.2). In this case, the values otherwise required decrease in direct proportion to the test piece cross section.

6.4.3 Flattening test

For the flattening test in the case of pressure welded tubes, one test piece shall be taken from each end of the sample tube. The relevant specifications given in DIN 50136 shall be observed for sampling.

6.4.4 Drift expanding test

For the drift expanding test in the case of pressure welded tubes, one test piece shall be taken from one end of the sample tube. The relevant specifications given in DIN 50135 shall be observed for sampling.

6.4.5 Bend test

For the bend test in the case of fusion welded tubes, two test pieces shall be taken from the sample tube transverse to the weld and with the weld in the center. The relevant specifications given in DIN 50121 Part 1 shall be observed for sampling. Before the test, the test pieces may be aged for six hours at 250°C to remove the hydrogen.

6.4.6 Chemical composition

For checking the chemical composition by a product analysis on the finished tube, or, at the manufacturer's discretion, on the starting product (sheet or strip), sample chips shall be taken at points uniformly distributed over the entire wall thickness of the product; a similar procedure shall be used for spectral analyses. As a general rule, Stahl-Eisen-Prufblatt 1805 shall apply for sampling.

6.5 Test procedure

6.5.1 The tensile test on the parent metal shall be carried out as specified in DIN 50140 or DIN 50145.

The tensile test transverse to the weld shall be carried out on test pieces as shown in figure 1 of DIN 50120 Part 1, September 1975 edition, or figure 2 of DIN 50120 Part 2, August 1978 edition.

If verification of the elevated temperature 0.2% proof stress has been agreed, this shall be determined as specified in DIN 50 145 at one of the test temperatures given in table 4.

6.5.1.1 ●● The test temperature may be specified at the time of ordering; if no test temperature has been specified, the test shall be carried out at 300°C.

6.5.2 The impact test shall be carried out as specified in DIN 50 115 on three test pieces. The specified minimum values shall apply for the mean obtained from three test pieces only one individual value may be lower than this specified minimum value, yet by not more than 30%.

Where the width of test pieces is not equal to 10mm (see sbuclause 6.4.2), the impact energy measured, Ax, in J, using the following formula:

where

Sx is the cross-sectional area of the test piece under the notch.

6.5.2.1 Testing shall be carried out at - 20°C for the basic series, at - 50°C for the high temperature series and at - 60°C for the special low temperature series, on test pieces taken as specified in subclause 6.4.2.

6.5.2.2 ●● Any other test temperature shall be agreed at the time of ordering.

6.5.3 The flattening test for pressure welded tubes shall be carried out as specified in DIN 50136, even in cases where the outside diameter exceeds 400mm. One test piece shall be tested with the weld in the 12o'clock position, and the other with the weld in the 3o'clock position.

The test pieces or tube ends shall be flattened until a specified distance between plates, *H*, is reached.

The following formula shall be used for calculating *H*, in mm:

where

s is the wall thickness, in mm;

dx is the outside diameter, in mm;

c is a constant having the following value;
0.07 for all steel grades with a minimum yield strength up to and including 355N/mm²
0.05 for steel grades with a minimum yield strength exceeding 355N/mm²

If the ratio s/dx exceeds a value of 0.15, *c* shall be reduced by 0.01 for the steel grades concerned.

6.5.4 In the case of pressure welded tubes the drift expanding test shall be carried out as specified in DIN 50 135, with the expansion as specified in table 8.

Table 8. Expansion in the drift expanding test

Steel grade	Expansion, in %, for a ratio of tube inside diameter (dx) to outside diameter (dx)	
	≤0.8	>0.8
StE 255, WStE 255, TStE 255, EStE 255	10	12
StE 385, WStE 285, TStE 285, EStE 285	8	10
StE 355, WStE 355, TStE 355, EStE 255	6	8
StE 420, WStE 420, TStE 420, EStE 420	6	8
StE 460, WStE 460, TStE 460, EStE 460	6	8

6.5.5 The bend test on fusion welded ubes shall be carried out as specified in DI 50 121 Part 1, January 1978 edition, figures 7 and 9, using mandrels the diameters of which are specified in table 3 of that standard. The bend angle shall not exceed 180°. One test piece shall be tested with its outer surface, the other with its inner surface subjected to tension, the weld being at the center of the test piece. No objection shall be raised to small cracks at the edge of the test piece or to local defects in the weld, e.g. pores or small inclusions, provided they do not affect the bending behavior of the test pieces.

6.5.6 The chemical composition shall be determined in accordance with the methods specified by the Chemists' committee of the Verein Deutscher Eisenhuttenleute (Society of German Ferrous Metallurgy Engineers) (see the "Standards and other documents referred to" clause).

6.5.7 In the hydraulic test (see also subclause 6.3.7.1) as specified in DIN 50 104, the test pressure shall be 80 bar.

6.5.7.1 ●● A higher test pressure may be agreed.

6.5.7.2 In no case, however, shall the safety margin with respect to the yield stress be lower than 1.1 (DIN 2413, June 1972 edition, subclause 4.6, Y'=0.9 shall be complied with). Where appropriate, this shall also apply in the case of thin-walled tubes with large outside diameters, even at 80 bar.

6.5.7.3 The test pressure shall be maintained for at least five seconds.

6.5.8 The appearance of the tubes shall be examined visually under appropriate lighting conditions by an inspector having normal vision.

Note. Subject to agreement between manufacturer and purchaser, any other suitable method of test may be used instead of the visual

examination.

6.5.9 Non-destructive testing

Non-destructive testing of the weld of pressure welded tubes shall be carried out as specified in Stahl-Eisen-Pruf-blatt 1917, test class B.

Non-destructive testing of fusion welded tubes shall be carried out as specified in Stahl-Eisen-Prufblatt 1916.

6.5.9.1 ●● Subject to agreement at the time of ordering, non-destructive testing of pressure welded tubes shall be carried out using the ultrasonic method as specified in Stahl-Eisen-Prufblatt 1915.

6.5.10 The wall thickness shall be measured at the ends of the tube using suitable measuring instruments.

6.5.11 The outside diameter shall be measured using suitable measuring instruments, as a two-point measurement or measurement of circumference. In the case of tubes sith outside diameters greater than 500mm, only the measurement of circumference shall be used.

6.5.12 For determining the circularity, a two-point measurement in one cross-sectional plane shall be made.

6.6 Retests

6.6.1 Tubes not satisfying the requirements when tested as specified in subclauses 6.5.7 to 6.5.12 (soundness test, visual examination, non-destructive testing, check on dimensions) shall be rejected.

The manufacturer's works shall have the right to take suit-able measures to remedy defects or to correct deviations found in these tests and to present these tubes for renewed acceptance inspection.

6.6.2 If one of the sample tubes fails the acceptance inspection including tensile test, impact test, flattening test or drift expanding test and bend test specified in sub-clauses 6.5.1 to 6.5.5, the manufacturer is justified in repeating the test giving unsatisfactory results on the same tube with twice the number of test pieces. All test pieces shall satisfy the requirements. If the requirements are still not satisfied in the new tests, the tube shall be rejected.

Two further tubes shall be taken from the batch concerned in place of the rejected sample tube and shall be submitted to the tests specified in subclauses 6.5.1 to 6.5.3. If one of the requirements is still not fulfilled, the entire batch shall be considered not to comply with the standard. However, testing of tubes individually may be agreed between the parties concerned.

If the unsatisfactory result of testing can be improved by means of heat treatment or other suitable measures, the supplier shall b given the opportunity to present a batch which was rejected for renewed acceptance inspection. If the test pieces continue to fail to satisfy the requirements, the entire batch shall be considered not to comply with the standard.

6.6.3 Test results attributable to improperly carried out sampling, sample preparation or test procedure, or to an accidental and local defect in a test piece shall be deemed invalid.

6.7 Materials testing certificates

6.7.1 Depending on the agreement made at the time of ordering (see subclause 6.1), either certificate

DIN 50049 - 3.1A (inspection certificate A),

DIN 50049 - 3.1B (inspection certificate B), or

DIN 50049 - 3.1C (inspection certificate C)

shall e issued for tubes complying with this standard. The type and scope of the tests, the responsibility for carrying out the tests and the type of certificate covering the tests are shown in table 9.

In each case, the technical rule agreed at the time of order-ing shall be specified.

6.7.2 The certificates shall state the marking of the tubes as specified in clause 7, the as delvered condition as speci-fied in subclause 5.2 and, subject to agreement, the steel-making process.

7 Marking

7.1 Every tube supplied in accordance with this standard shall be clearly and durably marked at one end, as follows:

- manufacturer's symbol;
- symbol identifying the steel grade;
- an appended symbol W indicating that the tube has been welded:
- inspector's mark;
- cast number or identification of cast;
- identification number for tubes with outside diameter not less than 159mm;
- mark indicating that a non-destructive test has been carried out, if testing has been agreed in accordance with subclause 5.9.

Table 9. Summary of the scope of test program and materials testing certificates (see figure 1 for sampling points and location of test pieces; see subclause 6.3.1 for batch size)

Testing			Scope of test program	Responsibility for carrying out the tests	Type of materials testing certificate as specified in DIN 50049
No.	Type of test	As in sub-clause			
1	Cast analysis	5.3.1	All characterizing elements per cast or casting unit.	Manufacturer	DIN 50049 - 2.2 1)
2	Tensile test	6.4.1 6.5.1	On two sample tubes from first two batches, from each further batch or from consignments of not more than 10 tubes, one test piece from each sample tube.	By agreement.	DIN 50049 - 3.1A or DIN 50049 - 3.1B or DIN 50049 - 3.1C
3	Impact test	6.4.2 6.5.2	At one end of sample tube specified above (No.2) for wall thicknesses not less than 5mm, one set of 3 test pieces.	By agreement.	DIN 50049 - 3.1A or DIN 50049 - 3.1B or DIN 50049 - 3.1C
4	Flattening test or drift expanding test	6.4.3	At each end of sample tube	By agreement.	DIN 50049 - 3.1A or DIN 50049 - 3.1B or DIN 50049 - 3.1C

		6.5.3	specified above (No.2) for wall thicknesses not exceeding 40mm, 1 test piece.		
5	Non-destructive testing of tube ends	6.3.4 6.5.7.1	At tube ends over a length of 25mm of sample tube specified above (No.2) for wall thicknesses exceeding 40mm.	Manufacturer	DIN 50049 - 2.2 1)
6	Non-destructive testing of tubes 2)	5.9 6.5.7.2	All tubes.	By agreement.	DIN 50049 - 3.1B
7	Soundness test	6.3.7.1 6.5.5	All tubes.	Manufacturer	DIN 50049 - 2.2 1)
8	Surface inspection	6.5.6	All tubes.	By agreement	DIN 50049 - 3.1A or DIN 50049 - 3.1B or DIN 50049 - 3.1C
9	Check on dimensions	6.5.8 6.5.9	All tubes.	By agreement	DIN 50049 - 3.1A or DIN 50049 - 3.1B or DIN 50049 - 3.1C
10	Product analysis 3)	6.4.4 6.5.4	By agreement.	Manufacturer	DIN 50049 - 3.1B
12	Reduction in area after fracture 4)	6.4.1.4	By agreement.	Manufacturer	DIN 50049 - 3.1B

1) This certificate may also be included in the next higher stage of document.

2) Non-destructive testing of the tubes is only to be carried out subject to agreement between the manufacturer and purchaser.

3) The product analysis is only to be carried out subject to agreement between the manufacturer and purchaser.

4) This property is to be tested only subject to agreement between the manufacturer and purchaser on test pieces taken transverse to the tube axis.

7.2 Marking shall generally be applied by stamping.

A different marking method (e.g. labeling the bundle of tubes) is also permitted for tubes with a small outside diameter and/or a small wall thickness.

8 Complaints

8.1 Under current law, a complaint may only be raised against defective tubes if the defects noticeably impair their processing and use. This shall apply unless otherwise agreed at the time of ordering.

8.2 It is normal and practical for the purchaser to give the supplier the opportunity to judge whether the complaints are justified, if possible by submitting the tube objected to or samples of the tubes supplied.